

# REPORT OF TEST

NIST Test # 39071S - Spectral Responsivity

for

UDT Sensors UV100 Silicon Photodiode, U1xxx

Submitted by:

Any Company

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(See your Purchase Order No. XXXX-XX, dated January 1, 1997)

## 1. Description of Test Material

The test photodiode, labeled U1xxx, is a UDT Sensors UV100 inverted layer silicon photodiode in an anodized aluminum mount with a removable precision aperture and a BNC connector. The active area of the photodiode is  $\approx 1 \text{ cm}^2$ .

## 2. Description of Test

The test photodiode was compared to two silicon photodiode working standards, U5xx and U5xx, using the NIST Ultraviolet (UV) monochromator-based comparator facility [1] from 200 nm to 500 nm in 5 nm increments. The spectral comparisons between the test photodiode and working standard photodiodes were performed using a double monochromator and an argon arc as the tunable monochromatic source.

The circular exit aperture of the UV monochromator was imaged ( $\approx f/5$ ) on the test photodiode, resulting in a beam diameter at the photodiode of 1.5 mm. The beam was centered on, and underfilled, the aperture.

The wavelength scale of the monochromator was calibrated with several laser and emission lines and is accurate to  $\pm 0.1 \text{ nm}$  over the entire spectral range. The bandpass of the monochromator was 4 nm. The short-circuit photocurrent from the test photodiode and each working standard photodiode was measured with a calibrated transimpedance amplifier. The test photodiode and each working standard photodiode were measured with zero bias voltage. Beam power fluctuations were monitored with a beamsplitter and silicon photodiode. The absolute spectral responsivity scale is based on a high accuracy cryogenic radiometer, with a relative expanded uncertainty ( $k = 2$ ) to absolute (SI) units of 0.2 %.

The spatial uniformity of the responsivity across the test photodiode photosensitive area was measured at 350 nm using the described comparator facility. The uniformity was measured in 0.5 mm increments using a 1.5 mm diameter beam.

Laboratory Environment:

Temperature:  $23.x \text{ }^\circ\text{C} \pm 0.8 \text{ }^\circ\text{C}$

Test Date: December 24, 1997

NIST Test No.: 844/xxxxxx-97/1

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Manufacturer: UDT Sensors

Model #: UV100

Serial #: U1xxx

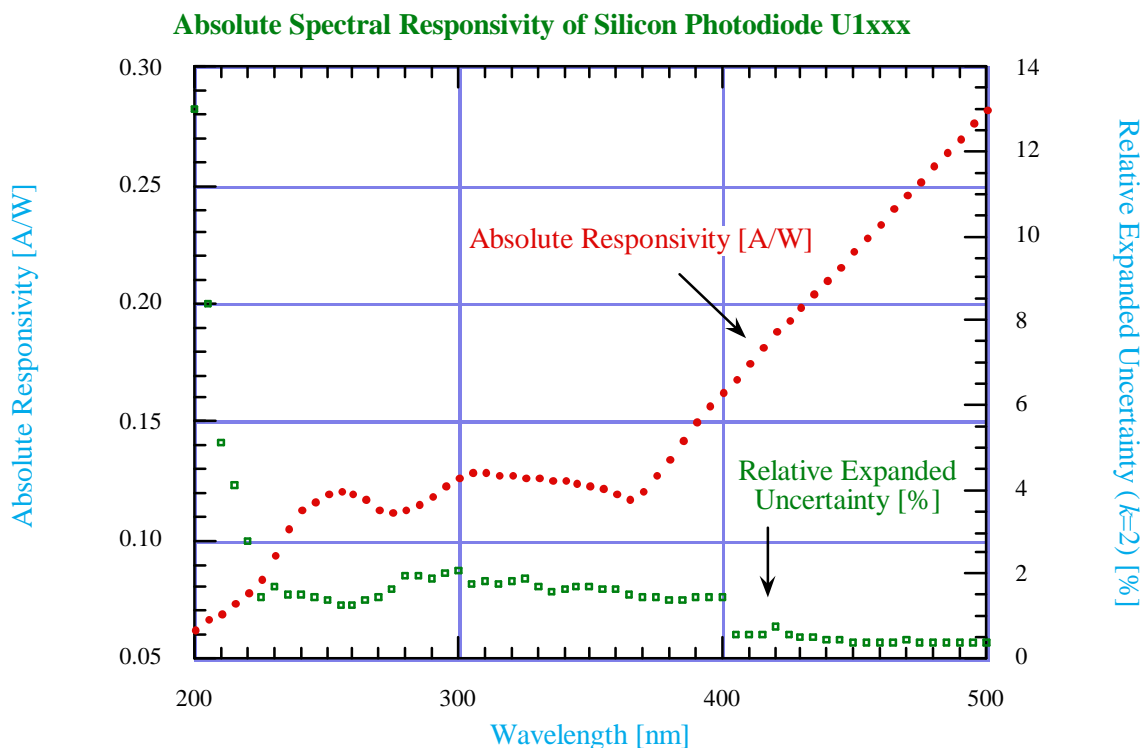
### 3. Results of Test

The absolute spectral responsivity in amperes per watt of the test photodiode is presented as a function of wavelength in table 1 and plotted in figure 1. The relative expanded uncertainties in the NIST absolute scale are described in Ref. [1]. The relative expanded uncertainty ( $k = 2$ ) presented as a function of wavelength for this measurement is stated relative to absolute (SI) units and is listed in table 1 and is plotted in figure 1.

Table 2 lists the dimensions of the precision aperture furnished with the test photodiode. The reported aperture area and distance from the aperture plate to the photodiode surface do not enter into the responsivity measurement results because the optical beam underfills the aperture. The uncertainty values reported with the aperture dimensions are expanded uncertainties.

Figure 2a is a plot of the uniformity of the test photodiode, showing 0.2 % contours at 350 nm of the deviations from the responsivity at the photodiode center. Figure 2b is a 3-dimensional plot showing the responsivity relative to the center of the photodiode. Note that the response of the photodiode can vary by as much as a percent over the active area. This can lead to errors larger than the stated uncertainties if the irradiation geometry is significantly different from the test conditions described in section 2.

Figure 1



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**Table 1**  
**Absolute Spectral Responsivity of Silicon Photodiode U1xxx**

Wavelength [nm]	Absolute Responsivity [A/W]	Relative Expanded Uncertainty ( $k = 2$ ) [%]	Wavelength [nm]	Absolute Responsivity [A/W]	Relative Expanded Uncertainty ( $k = 2$ ) [%]
200	6.28E-2	13	350	1.24E-1	1.7
205	6.68E-2	8.4	355	1.22E-1	1.6
210	6.95E-2	5.1	360	1.20E-1	1.6
215	7.34E-2	4.1	365	1.18E-1	1.5
220	7.78E-2	2.8	370	1.21E-1	1.5
225	8.42E-2	1.5	375	1.27E-1	1.5
230	9.45E-2	1.7	380	1.35E-1	1.4
235	1.06E-1	1.5	385	1.43E-1	1.4
240	1.13E-1	1.5	390	1.50E-1	1.4
245	1.17E-1	1.4	395	1.57E-1	1.4
250	1.19E-1	1.4	400	1.63E-1	1.5
255	1.21E-1	1.3	405	1.689E-1	0.60
260	1.20E-1	1.3	410	1.750E-1	0.56
265	1.17E-1	1.4	415	1.816E-1	0.58
270	1.13E-1	1.5	420	1.882E-1	0.76
275	1.12E-1	1.7	425	1.935E-1	0.60
280	1.13E-1	2.0	430	1.993E-1	0.54
285	1.15E-1	2.0	435	2.049E-1	0.50
290	1.19E-1	1.9	440	2.100E-1	0.42
295	1.24E-1	2.0	445	2.160E-1	0.42
300	1.27E-1	2.1	450	2.220E-1	0.38
305	1.29E-1	1.8	455	2.281E-1	0.38
310	1.29E-1	1.8	460	2.341E-1	0.40
315	1.28E-1	1.8	465	2.401E-1	0.38
320	1.27E-1	1.8	470	2.462E-1	0.42
325	1.27E-1	1.9	475	2.523E-1	0.40
330	1.26E-1	1.7	480	2.583E-1	0.38
335	1.26E-1	1.6	485	2.643E-1	0.40
340	1.25E-1	1.6	490	2.704E-1	0.38
345	1.25E-1	1.7	495	2.764E-1	0.40
			500	2.824E-1	0.38

**Table 2**  
**Aperture Dimensions**

Area:  $0.5xxx \pm 0.0005 \text{ cm}^2$

Distance from aperture plane  
to photodiode surface:  $4.8 \pm 0.4 \text{ mm}$

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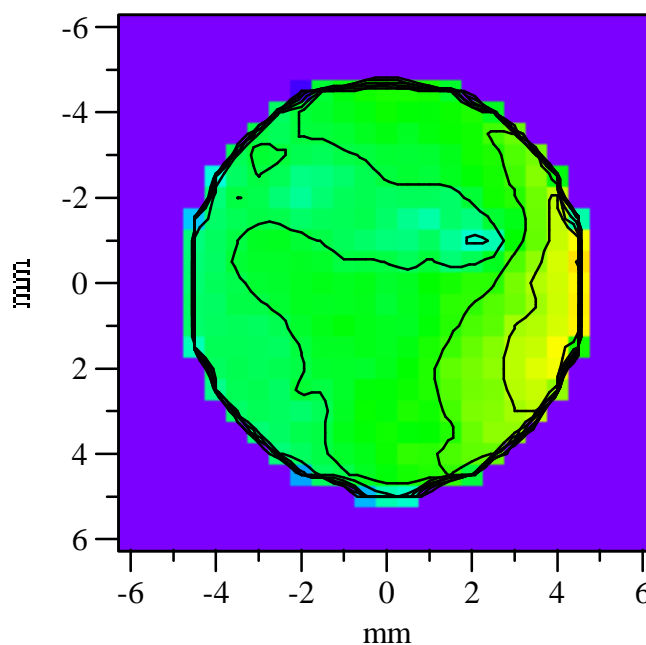
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Manufacturer: UDT Sensors

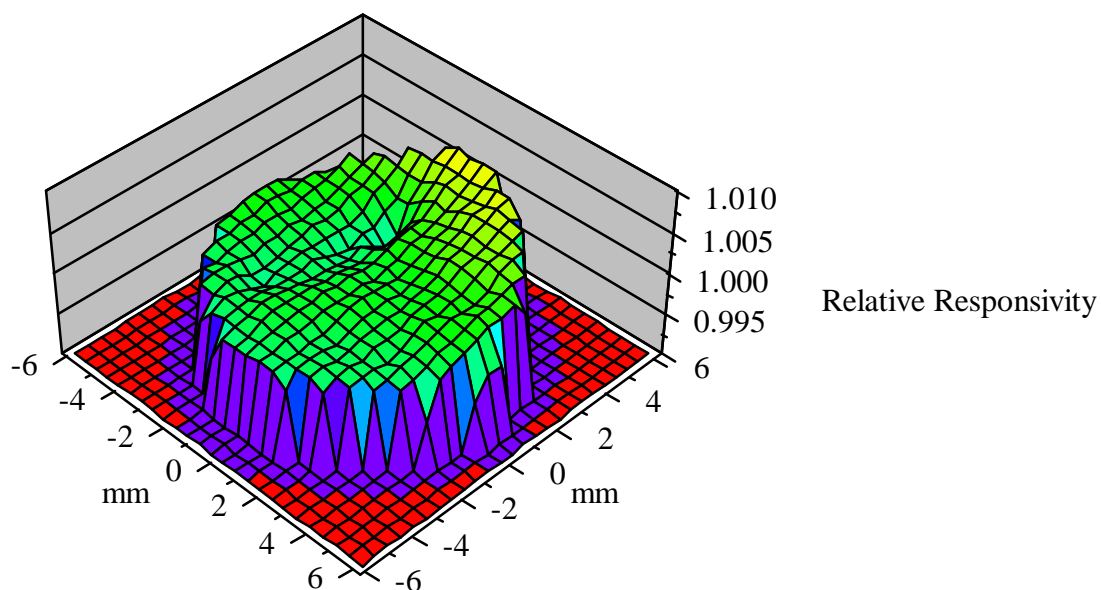
Model #: UV100

Serial #: U1xxx

**Figure 2a**  
**Responsivity Uniformity of Silicon Photodiode U1xxx**  
**0.2 % contours at 350 nm; 1.5 mm resolution; 0.5 mm/Step**



**Figure 2b**  
**Surface Plot of Responsivity Relative to**  
**Center of Photodiode for Silicon Photodiode U1xxx**  
**at 350 nm; 0.5 mm/Step**



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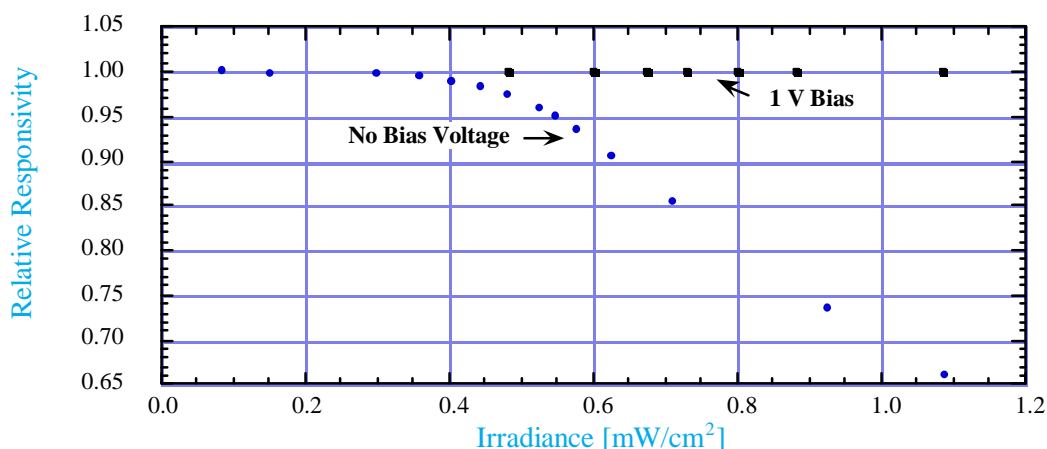
Serial #: U1xxx

### 4. General Information

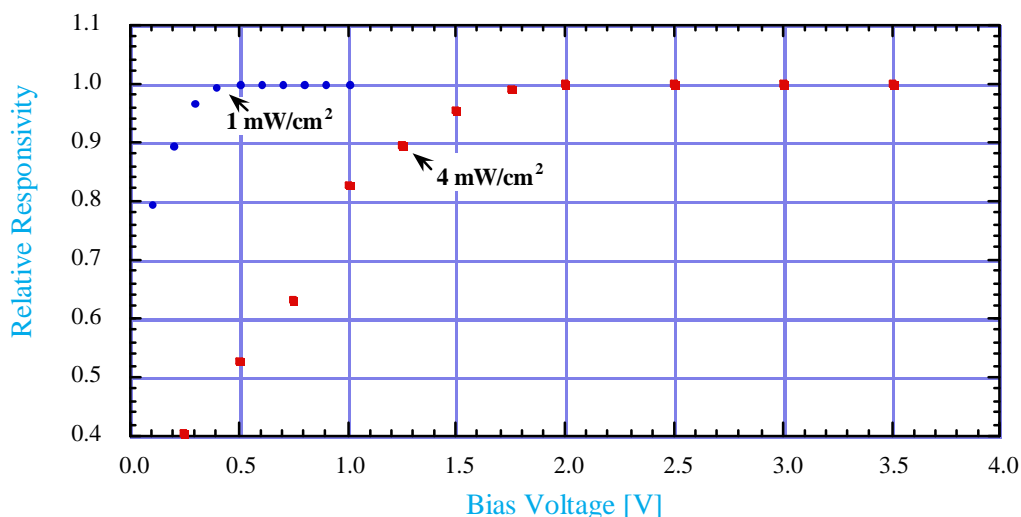
The linearity of this type of photodiode is shown in figure 3 at 442 nm at irradiance levels from  $0.1 \text{ mW/cm}^2$  to  $1.1 \text{ mW/cm}^2$  with and without a reverse bias voltage. Each data point represents the ratio of the photodiode responsivity at the indicated irradiance to the responsivity within the linear region. The linearity was measured by using a beamsplitter to irradiate two photodiodes at approximately a 10:1 intensity ratio, with the diode aperture filled and uniformly irradiated. The linearity is dependent on the irradiation geometry and will differ for spot sizes significantly smaller than the aperture size.

The change in the responsivity for this type of photodiode at 442 nm is shown in figure 4 as a function of bias voltage. For wavelengths shorter than 450 nm, a 1 V bias can be used to improve the linearity of the photodiode without significantly changing the spectral responsivity. There will however be some leakage current which will limit the minimum usable signal.

**Figure 3**  
**Linearity of UDT Sensors UV100 at 442 nm**



**Figure 4**  
**Responsivity dependence to bias voltage of UDT Sensors UV100 at 442 nm**



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A documentation appendix includes operating instructions for the test photodiode. The laboratory temperature is reported for information only. It is not intended that this data be used for corrections to the spectral responsivity data in this report. This report shall not be reproduced, except in full, without the written approval of NIST.

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**Reference:**

- [1] T. C. Larason, S. S. Bruce, and A. C. Parr, NIST Measurement Services: Spectroradiometric Detector Measurements: Part I - Ultraviolet Detectors and Part II - Visible to Near-Infrared Detectors, Natl. Inst. Stand. Technol., Spec. Publ. 250-41 (1998).

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**APPENDIX:****OPERATING INSTRUCTIONS  
FOR  
NIST PHOTODIODE**

The NIST characterized photodiode consists of a silicon photodiode with a removable precision aperture, a quartz window, and a BNC connector.

- A. The photodiode should be rigidly mounted on a dual-axis tilt mount such that the photodiode can be tilted about two orthogonal axis. The photodiode should be adjusted to be perpendicular to the incident radiation.
- B. The incident beam of radiation should be smaller than the aperture, and should be centered in the photodiode aperture.
- C. The photodiode should be connected with a BNC cable to an electrometer grade amplifier (transimpedance amplifier) which measures the current from the photodiode.
- D. The inside edge of the precision aperture is extremely delicate and should not be touched with fingers or any other object.
- E. The diode window can be cleaned with lens tissue and spectral grade solvent. The precision aperture should be removed before cleaning the photodiode window.